

2.17 DECISION LOGIC

There are three types of decision processes used in Brawler: value-driven decisions, traditional decision rules, and production rules. Traditional decision rules are composed of software trees that branch according to tests on environmental conditions. At the bottom of each path of the tree is the action or decision that is appropriate. Many of the simpler decisions are made on the basis of decision rules.

Production rules consist of a list of condition-action pairs. The list is scanned and each time the condition half of a rule is met, the action specified is performed. The actions include both actual decision alternatives and the setting of condition variables to be used by other production rules. One advantage of production rules over decision trees is that they are not “hardwired” in compiled software. Thus, production rules may easily be changed to fine-tune behavior for specific scenarios.

Figure 2.17-1 shows the value-driven human decision processes used in Brawler. The upper loop is intended to represent the mental model-building process and is executed each time a pilot becomes conscious. Model-building is referred to here in the sense of assigning values to the variables that describe the situation, not, of course, in the sense of deriving the models of how aircraft and other objects in the simulation interact.

The lower loop is executed each time a decision is made. It is important to note that each time a consciousness event occurs, a pilot may make several distinct decisions. These decisions form a decision hierarchy to be described shortly. The lower loop is traversed once for each alternative course of action being considered. The alternative generator produces a candidate alternative, the mental model predicts what the situation will be if the alternative is implemented, and an evaluation model places a numerical score on the resulting situation. When all promising alternative actions have been considered in this

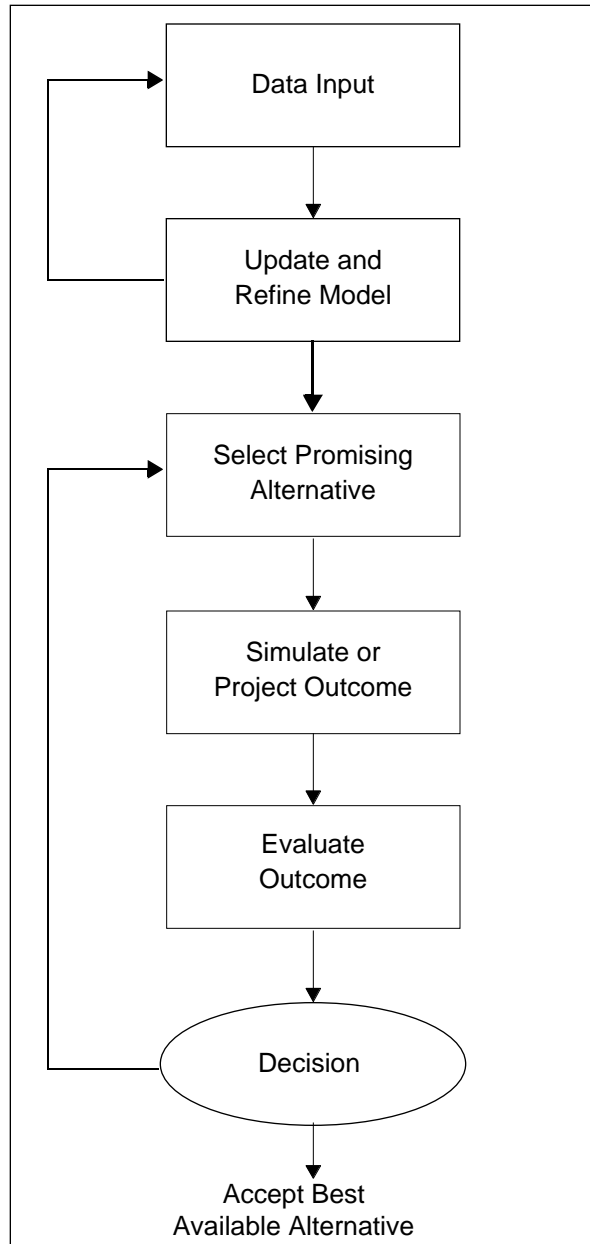


FIGURE 2.17-1. The Human Decision Process
(A Standard or Canonical Taxonomy).

way, the highest scoring one is implemented. Once a decision is made, the pilot is not committed to continue this course of action. During subsequent consciousness events he reconsiders what he is doing and is free to change his mind. This reconsideration occurs at least once per second for decisions that influence the physical state of the aircraft, such as the selection of a desired vector velocity. Decisions made at a higher level, such as those which determine flight-level tactics, are routinely considered at longer intervals. Unexpected events, however, such as the detection of new aircraft, trigger early reconsiderations of decisions.

Figure 2.17-2 shows the hierarchy of decisions made decision-making elements (DMEs). The primary effect of high-level decisions is to control the lower level decisions by modifying their evaluation functions and by determining which lower level alternative actions will be considered.

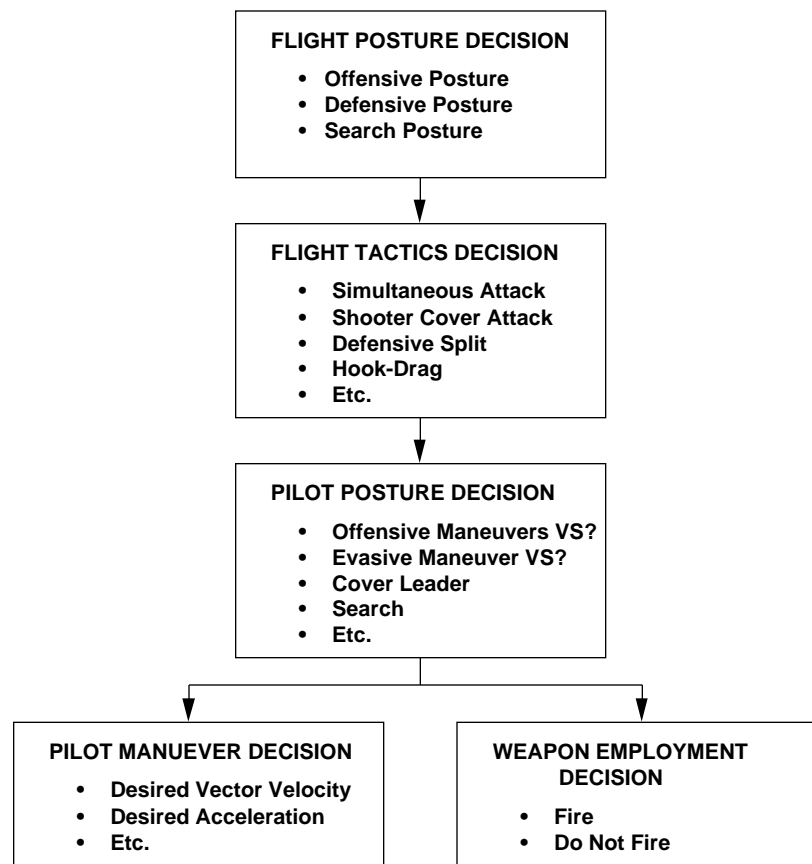


FIGURE 2.17-2. Brawler Decision Hierarchy.

The flight posture decision occurs at the highest level and determines the general course of action. It is made on the basis of a broad description of the situation, such as force ratios and engagement geometry, and also on the basis of user-supplied combat priorities. At the next, level the flight leader determines the tactics that should be used to implement the flight posture. As a result of this decision, a specific communication is sent to other

members of the flight, informing them of the tactics. The effect of the message is to influence the values that other pilots use to score the alternative actions they consider.

The pilot posture decision determines the general course of action of a pilot: who is he attacking, or who is he evading, or is he just providing support for his leader? The pilot posture decision is also responsible for selecting a weapon and deciding if the current weapons objective is one of “get the target into the weapons envelope,” “aim weapon,” or a mixture of the two objectives. In addition, the pilot posture decision also determines the radar mode that is most appropriate; the pilot may choose scan mode (plus a specification of bars and elevation angle), track-while-scan mode (if available), or he may choose to try to obtain (or maintain) lock on a particular hostile.

The maneuver decision and the weapon employment decisions occur at the lowest level. The alternatives considered by the maneuver decision are maneuvers designed to do things like “get on the hostile's tail,” “gain specific energy versus a hostile,” “avoid the ground,” and “force a pursuer to overshoot.” They are scored by a value function that is sensitive to such factors as relative positions and orientation, specific energy advantages, and the ability to see other aircraft.

The weapon employment decision determines, given a prior decision as to what weapon is most suitable, whether to fire the weapon at this moment. It is based on a pilot's perception of whether the opponent is in the weapon's envelope, whether there is an opportunity to improve the shot by waiting, and whether there is a risk from other hostiles by continuing to press in.

2.17.1 Functional Element Design Requirements

This section presents requirements necessary to implement Decision Logic functions in Brawler. Because this is an upper level function with several FEs beneath it, only top level requirements will be addressed in this section. Functions performed at this level will be applicable to all decisions made at lower levels, which deal with posture, tactics, radars, weapons, and maneuvers. This function will be executed when consciousness events are scheduled for each pilot and will control simulation of lower level decisions.

- a. Brawler will establish a time interval for projection of currently perceived situations into the future. This time interval will be used to calculate values associated with each type of decision and will be based upon current situation factors.
- b. Brawler will project the states (position, velocity, acceleration, mode, etc.) of all entities other than the pilot's aircraft into the future so that they can be assessed with respect to factors significant for each decision type.
- c. Brawler will determine whether certain types of decisions will be made using the built-in (default) pilot decision logic or via production rules provided by the model user.
- d. Brawler will establish the decision levels to be followed when making lower level decisions, which will affect the manner in which various factors are considered.

- e. Brawler will enable simulation of pilot decision logic via projection and evaluation of factors related to each type of decision. The results of each will be used to update and maintain pilot perception of the situation as well as effect changes to state variables that result from those decisions.

2.17.2 Functional Element Design Approach

The following design elements describe the Decision Logic function performed at this level of the process. Results of this function are applicable to lower level decision functions.

Design Element 17-1: Compute Think-Ahead Time

The projection, or think-ahead time depends upon the current situation. Specifically, it is a function of range to hostiles and imminence of weapon firing.

Design Element 17-2: Project Other Entity States

All other aircraft of which the pilot is aware are projected forward in time using a constant acceleration projection. In order to hedge between what the aircraft are currently doing and the envelope of their potential maneuvers, the acceleration used is one-half of the currently perceived acceleration for each aircraft. The pilot's own aircraft is projected forward by the same amount, but using a constant velocity (no acceleration) projection.

Design Element 17-3: Set Decision Level

The decision levels in the current Brawler decision hierarchy are numbered in the order in which they were implemented. The order of implementation was flight tactics, pilot posture, maneuver, flight posture, element posture (now unused), element tactics (now unused), and weapons firing. For this reason, the decision levels are not numbered sequentially. During a consciousness event, Brawler begins at the highest level in the hierarchy and works down to the lowest, using an indexing array to keep track of the number of the current decision level.

2.17.3 Functional Element Software Design

2.17.4 Assumptions and Limitations

2.17.5 Known Problems or Anomalies